Diffusion and mixing in dense granular flows

Arshad Kudrolli, Clark University, DMR Award# 9983659

Motivation

• To measure the transport properties of dense granular flow with the aim of developing a statistical theory of granular materials. The issue is relevant to segregation and mixing in industrial applications ranging from pharmaceuticals to nuclear pebble bed reactors

Results

• Tracked the positions of the particle both in space and time to unprecedented accuracy in dense flows

• The mean flow is described by the diffusing-void model of granular flow. However, the fluctuations about the mean is orders of magnitude smaller than that anticipated by the model

• The Peclet number (Pe) which gives a measure of the diffusion is of $O(10^2)$ indicating that the flow is advection dominated

• A new "spot" model which incorporates correlations developed by Martin Bazant appears to capture the observations

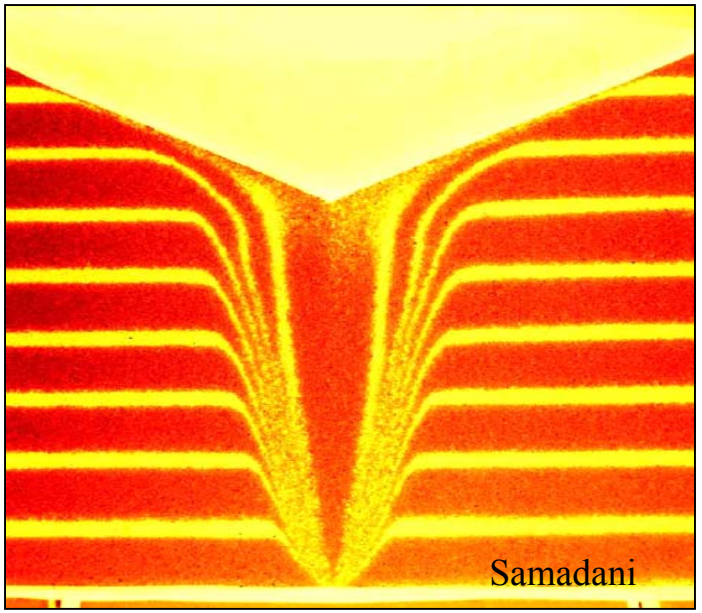

Figure: Grains flowing inside a silo as it drains. The flow is confined to a parabolic region deep inside the silo. The interface between region with different color grains remains sharp even as they travel through the entire silo thus showing lack of mixing. The size of the image is 45 cm x 45 cm and the mean grain diameter is 0.5 cm.

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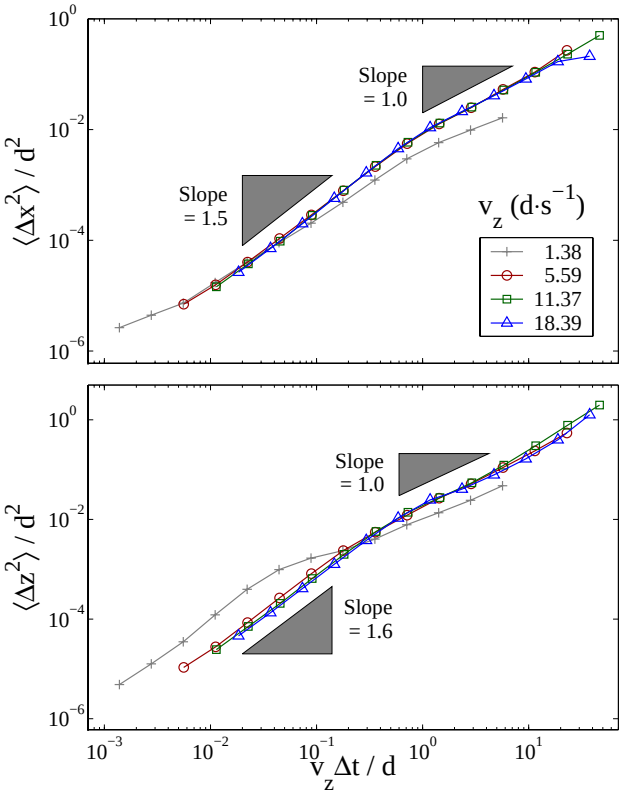
Figure: The mean square of the fluctuation of the particle positions perpendicular and along the flow direction obtained by direct particle tracking. A crossover to a diffusive regime is observed over long times and flow distances. However note that the net diffusion compared to the particle diameter d is very small. The data is observed to collapse after appropriate scaling

Work in collaboration with the dry fluids group at MIT



v_z: mean flow speed

Educational impact and outreach:

- Training of two graduate students. Daniel Blair defended his PhD dissertation in October and is now a post-doc at Harvard University. Jaeyuk Choi is a graduate student at MIT.
- The PI has made presentations at high schools on the physics of granular materials.
- A demonstration has been built and placed in the foyer of the Science Building at Clark Univ.

Relevant preprints/publications

1. Diffusion and mixing in gravity-driven dense granular flows," J. Choi, A. Kudrolli, R.R. Rosales, and M.Z. Bazant, submitted to Phys. Rev. Lett. (2003).
2. Collision statistics of driven granular materials, D.L. Blair and A. Kudrolli, Phys. Rev. E **67**, 041301 (2003).